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SOME STUDIES ON FABRIC TORSION AND FABRIC PROPERTIES

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ABSTRACT

Aesthetic appearance is the important parameter of performance of clothing. When fabric undergoes external compressive and torsional forces fabric will bend and buckle in different direction and hence wrinkle will be formed. Thus garment appearance affected by fabric parameters such as bending, torsion and drape. The bending and fabric weight have effect on torsion.

KEYWORDS: Fabric Bending, Drape, Torque

INTRODUCTION

Aesthetic appearance is one of the most important criteria used by consumer in judging the total performance of clothing. The appearance of garment depends on quality of fabric, seams used in manufacturing. The fabric parameters such as bending, drape and torsion influence garment appearance.

Fabric drape refers to the manner in which fabric falls, shapes, flows with a model or human body as well as on furniture and wall hanging when only part of it directly supported. Drape is defined as the extent to which a fabric will deform when it is allowed to hang under its own weight (1). The bending rigidity is measure of resistance offered by the fabric to bending (2). Fabric is considered to be very flexible material, which is highly affected by its own weight causing large deflection. It has been considered that when a fabric undergoes influence of external compression and torsional forces the fabric will bend and buckle in different directions and hence wrinkle will be formed in the fabric (3, 4, 5). Thus torsional properties of fabric are important in clothing manufacturing, washing, and wear and dry cleaning process.

Torque makes material to twist and one end rotates and other inducing shear stress on any cross section, during body moments such as the lifting arms, walking, sleeves fold and backside of trouser legs, wrangling washed garments under goes different deformations such as bending, drape and torsion.

SAINT – VENANT TORSION THEORY

The important results from the Saint–Venant torsion (6) theory can be summarised in terms of stress function $\phi(x, y)$, as below.

General torsion equation: $$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = -2G\theta \qquad (1)$$

G is the shear modulus and **θ** is the angle of twist.

Boundary condition: $\phi = 0$ on a boundary (2)

By using 1 and 2 we can get torque T as follows

$$T = 2\iint \phi \, dx \, dy \tag{3}$$

L Prandtl (6) introduced membrane analogy to solve torsional problem, in case of narrow rectangular cross section this analogy gives very simple solution as provided by equation -3.

Maximum shear stress (4)

In which b is the longer side and c the shorter side of the rectangular cross section and **α**is a numerical factor depends on ratio of b/c.

The angle of twist per unit length in the case of test specimen with rectangular cross section is given below.

$$\theta = \frac{TL}{C} \tag{5}$$

Where C is called torsional rigidity constant, given by C= 1/3 bc^3G and L is length of cross section.

MATERIALS AND METHODS

Materials

Ten different samples of cotton shirting fabrics are chosen.The construction particulars of the sample are given in Table 1.

Table 1: Geometric Properties

Sl. No	Linear Density (Tex)		Yarn Density (Per cm)		Thickness	Aerial Density	Crimp %		Cloth Cover
	N1	N2	n1	n2	cm	GSM	Warp	Weft	
1	12	13	46	31	0.024	146.80	8	6	0.77
2	10	10	47	31	0.023	139.30	7	6	0.73
3	12	13	49	31	0.028	158.60	9	6	0.79
4	13	14	49	31	0.028	160.70	12	8	0.81
5	14	15	45	31	0.025	126.90	5	4	0.79
6	15	15	47	31	0.027	130.90	11	9	0.82
7	14	16	44	30	0.028	130.47	11	7	0.79
8	27	23	42	22	0.036	202.08	7	6	0.88
9	27	27	38	33	0.035	211.94	10	4	0.90
10	19	19	47	24	0.028	134.50	5	3	0.85

METHODS

Drape Coefficient

Drape of the fabric was evaluated by drape meter as per the ASTM D 5050 test method to determine the drape coefficient of the fabrics under study

$$\text{Drape co-efficient} = \frac{A_d - S_1}{S_2 - S_1} \times 100 \tag{6}$$

Where, A_d, S_1, and $S_2$are the area of the vertical projection of the draping sample fabric (cm^2), the area of the round sample holder (cm^2), and the area of the sample (cm^2), respectively.

BENDING LENGTH

Bending length, c, is defined as the length of fabric which will bend under its own weight to a definite extent. It is a measure of the stiffness that determines draping quality.

$$c = lf_1(\theta)\text{, where } f_1(\theta) = \left(\frac{\cos\frac{1}{2}\theta}{8\tan\theta} \right)^{\frac{1}{2}} \tag{7}$$

Flexural rigidity, *G*, this is a measure of stiffness associated with the handle.

$$G = wc^3 \text{ g-cm} \tag{8}$$

Where, w = cloth weight in gram per square centimetre.

Bending modulus, *q*, this is independent of the dimensions of the fabric and is called as the intrinsic stiffness. This value is used to compare stiffness of fabrics of different thickness.

$$q = \frac{12G \times 10^{-3}}{g^3} \text{ g / cm}^2 \tag{9}$$

Where, g is cloth thickness in cm, measured at a pressure of 1pounds per square inch (70.3 g/cm^2).

TORSION TEST

The torsion behaviour of fabric under axial twist is measured. The specimen is mounted between non rotating jaw assembly and a rotating jaw assembly in a rectangular sheet form. The non rotating jaw is fixed at one end of frame and rotating jaw can be moveable. The non rotating jaw assembly includes device to measure the applied torque. To test the fabric the required gauge length is adjusted and tested.

RESULTS AND DISCUSSIONS

Fabric Torsion Tests: The torsion is measured using torsion tester. The data's obtained from experiment are given in Table 2.

Table 2: Angle of Torsion and Torque

Sl. No	Angle of Twist (Radians)		Torque (N-m)	
	Warp	Weft	Warp	Weft
1	2.20	2.20	0.06	0.05
2	2.20	2.20	0.06	0.04
3	1.89	1.57	0.04	0.03
4	2.04	2.04	0.04	0.04
5	2.51	2.04	0.03	0.04

Table 2: Contd.,

6	2.20	2.20	0.04	0.04
7	2.20	2.04	0.04	0.06
8	2.20	2.04	0.08	0.08
9	2.20	2.20	0.09	0.06
10	2.04	2.20	0.07	0.04

From above table it can be seen that fabric 8, 9 & 10 having more torque value in warp direction.

Effects of aerial density and thickness on torque have been plotted as fallows.

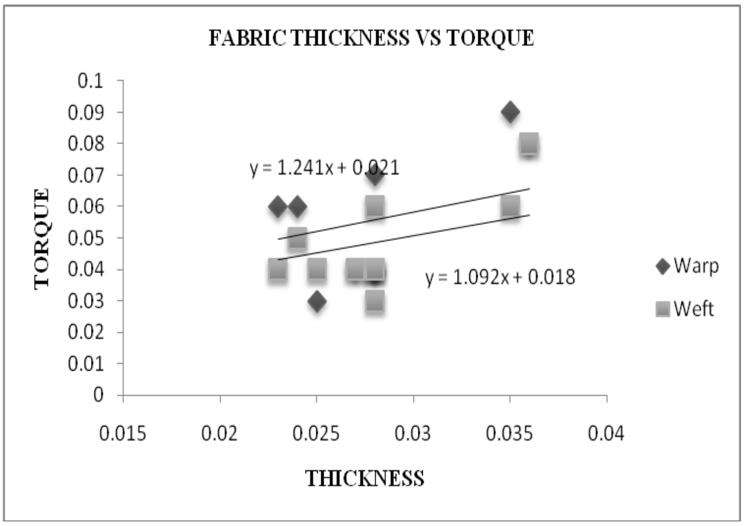

Figure 1

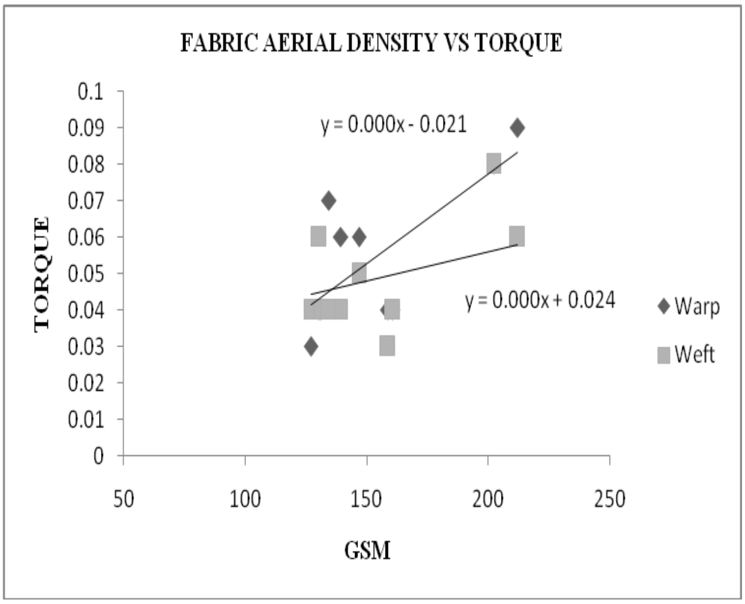

Figure 2

From the above graph we can conclude that thickness and fabric weight having positive relation with torque.

Fabric Bending and Drape Tests: In orders to correlate the results obtained from torsion test, fabric bending and drape have been conducted. Bending rigidity, bending modulus and Drape ability of 10 different fabrics have been given in table 3.

Table 3: Aesthetic Properties

Sl. No	Bending Rigidity (mgm-cm)		Bending Modulus (Kg/cm^2)		Drape Coefficient
	Warp	Weft	Warp	Weft	%
1	158.45	143.87	137.55	124.89	55.90
2	136.52	104.89	134.65	103.45	49.89
3	141.70	164.31	77.46	89.82	56.63
4	203.27	132.26	111.12	72.30	49.93
5	183.89	107.34	141.23	82.44	53.0
6	169.88	125.61	103.57	76.58	55.66
7	132.03	153.62	72.18	83.98	38.91
8	426.01	337.56	105.13	83.30	63.30
9	264.24	377.90	70.88	101.36	60.07
10	246.77	111.69	134.88	61.05	53.27

The relation between torque values with other handle related properties of fabrics has shown below.

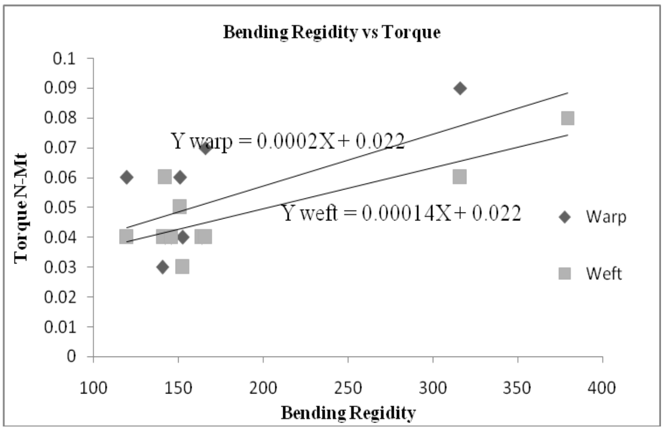

Figure 3

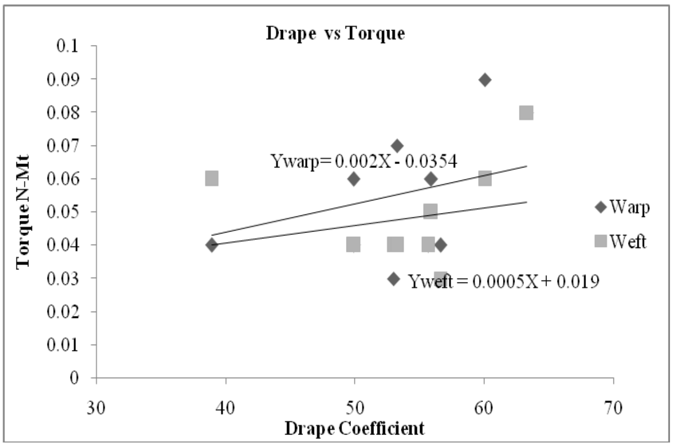

Figure 4

From the above figure it shows torque having good relation with bending rigidity and drape in warp direction

Table 4: Correlation Values

Torque	Thickness	Fabric Aerial Density	Bending Regidity	Drape
Warp	0.63	0.74	0.66	0.56
Weft	0.71	0.60	0.60	0.60

The table indicates positive correlation between torque with thickness ,GSM,bending regidity and drape.

CONCLUSIONS

The aim of this paper is evaluation of fabric torsion and some effect of fabric parameters on torque of woven cotton shirting fabric. Experimental torque value shows good agreement with fabric parameters such as thickness and fabric weight.Fabric weight and bending rigidity has more effect on torque.

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